TITLE OF THE INVENTION

INFORMATION PROCESSING APPARATUS AND METHOD, COMPUTER-READABLE MEMORY, AND PROGRAM

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BACKGROUND OF THE INVENTION

Field of the Invention

[0001]   The present invention relates to an information processing apparatus and method for processing data which is input through a coordinate input device, a computer-readable memory, and a program.

Description of the Related Art

[0002]   A so-called signature authentication system has been well known which uses a signature to verify the authenticity of a user. Such a system typically employs a signature authentication method as disclosed in Japanese Patent Laid-Open No. 10-143668 and No. 10-171926 entitled "HANDWRITTEN CHARACTER STRING VERIFICATION METHOD AND APPARATUS." In this method, user writing data functioning as a password is used to verify a handwritten character string. Unlike passwords, however, writing data contains features specific to individuals, and others who enter the same word as that of one person might not be verified. The features include the shape of the written character,

character writing order, character writing speed, and rhythm.

[0003]   In this signature authentication method using a handwritten character string verification technique, an input device, known as a digitizer, is used to input signature data of a user to a computer in order to perform signature authentication. The handwritten character string verification technique is achieved by dynamic programming (DP) matching time-series data, such as coordinate data, writing pressure data, or writing speed data, which is captured using a digitizer, with the registration data that has been registered in a verification dictionary.

[0004]   As further disclosed in Japanese Patent Laid-Open No. 9-81518 and No. 9-81519 entitled "VERIFICATION METHOD ON NETWORK," writing data is exchanged on a server-client system, allowing the same writing data to be used as a password in different environments such as homes and offices.

[0005]   In the related art, techniques using a digitizer include a handwritten character recognition technique to recognize handwritten characters plotted with pens, and a handwriting word processor in which characters or pictures plotted with pens are filed as data.

[0006]   However, such a signature authentication method in the related art has caused a large difference in quality of the captured writing data depending upon the capabilities of the digitizers. In particular, in a client-server system,

the signature authentication method has experienced a
problem in that a user does not always use the same
digitizer in the client, and the writing data transmitted
from the client to the server may sometimes greatly differ.
Digitizers having different processing rates would make the
detected coordinates different, and the signature data
itself may therefore be different, thereby prohibiting
satisfactory authentication.

[0007]   A handwritten character recognition technique and
a handwriting word processor (handwriting stroke database)
technique also have a problem in that the performance
depends upon the capability of the digitizer.

SUMMARY OF THE INVENTION

[0008]   Accordingly, it is an object of the present
invention to allow signatures which are entered using
digitizers having different processing rates to be
registered and verified. Therefore, signatures signed by a
user using different client devices can be verified by a
server.

[0009]   To this end, in one aspect of the present
invention, an information processing apparatus which
processes data input through a coordinate input device
includes a detector which detects the sampling rate of the

coordinate input device, and a standardizer which standardizes writing data which is input through the coordinate input device based on the sampling rate detected by the detector.

[0010] The information processing apparatus may further include a transmitter which transmits the standardized writing data to a verification server for signature verification.

[0011] In another aspect of the present invention, a verification server linked to an information processing apparatus having different coordinate input devices over a network includes a receiver which receives standardized writing data which is transmitted. The standardized writing data is generated by standardizing writing data which is input through a coordinate input device in the information processing apparatus based on the sampling rate of that coordinate input device. The verification server further includes a signature verifier which performs signature verification based on the standardized writing data received by the receiver.

[0012] Other features and advantages of the patent invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]   The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and, together with the description, serve to explain the principles of the invention.

[0014]   Fig. 1 is a block diagram of an information processing apparatus according to a first embodiment of the present invention.

[0015]   Fig. 2 is a flowchart of the process executed by a sampling rate detector according to the first embodiment.

[0016]   Fig. 3 is a view of an example operation of the sampling rate detector according to the first embodiment.

[0017]   Fig. 4 is a flowchart of the process executed by a writing data standardizer according to the first embodiment.

[0018]   Fig. 5 shows an example data structure of time-stamped writing data according to the first embodiment.

[0019]   Fig. 6 is a schematic view of the operation of the writing data standardizer according to the first embodiment.

[0020]   Fig. 7 is a flowchart of the process executed by the writing data standardizer according to the first embodiment.

[0021]   Fig. 8 is a view showing calculation of an

interpolated point according to the first embodiment.

[0022]   Fig. 9 is a block diagram of an information processing apparatus according to a third embodiment of the present invention.

[0023]   Fig. 10 is a block diagram of an information processing apparatus according to a fourth embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024]   Preferred embodiments of the present invention will now be described in detail with reference to the drawings.

[0025]

First Embodiment

    Fig. 1 is a block diagram of an information processing apparatus according to a first embodiment of the present invention.

[0026]   A coordinate input device 101 comprises the above-noted "digitizer," and captures coordinate time-series data which is input through an input device such as a pen. Some digitizers can capture information including writing pressure and writing speed. Writing data (stroke data) 102 is input using the coordinate input device 101.

[0027]   A sampling rate detector 103 detects the sampling

rate which is used for detection of the coordinate input
which is one characteristic of the digitizer. A writing
data standardizer 104 standardizes the writing data 102
based on the detected sampling rate. The thus standardized
writing data 105 may be absolute time interval information
which does not depend upon characteristics of the digitizer
or characteristics of the information processing apparatus
to which the writing data 102 is input.

[0028]   A signature register 106 is executed to initially
register the standardized writing data 105 of a user in a
signature dictionary database 107 as signature dictionary
data in order to verify the signature when the user uses the
information processing apparatus. The signature dictionary
database 107 manages to associate the identification
information used to identify users of the information
processing apparatus with the signature dictionary data.

[0029]   Once a user requests access to the information
processing apparatus, a signature verifier 108 refers to the
signature dictionary database 107 having the signature data
of that user pre-registered therein. The signature verifier
108 then verifies the registered signature dictionary data
of that user with the standardized writing data 105
generated from the writing data which is newly input by the
user to authenticate the signature. A verification result
output unit 109 outputs the verification result, and the

signature verification process is completed.

[0030]   In the first embodiment, a program that controls the sampling rate detector 103, the writing data standardizer 104, the signature register 106, the signature dictionary database 107, the signature verifier 108, and the verification result output unit 109 is installed in a single information processing apparatus. Since the program is used to standardize the writing data, a single program which is installed in an information processing apparatus having different kinds of digitizers would support the digitizers.

[0031]   The process executed by the sampling rate detector 103 is described below with reference to Fig. 2.

[0032]   Fig. 2 is a flowchart of the process executed by the sampling rate detector 103 according to the first embodiment.

[0033]   First, at step S201, the information processing apparatus displays a certain graphical pattern for sampling rate detection on an input screen of the coordinate input device 101 to instruct the user to trace this graphical pattern using a pen.

[0034]   At step S202, the user's pen input on the graphical pattern for sampling rate detection is detected to determine an input time period from the beginning to the end of the pen input and the total number of samplings during the input time period.

[0035]   At step S203, the sampling rate per unit time is calculated based on the determined input time period and total number of samplings.   The calculated sampling rate is output to the writing data standardizer 104.

[0036]   An example operation of the sampling rate detector 103 is described below with reference to Fig. 3.

[0037]   Fig. 3 shows an example operation of the sampling rate detector 103 according to the first embodiment.

[0038]   In Fig. 3, by way of example, a graphical pattern "W" for sampling rate detection is displayed on the input screen of the coordinate input device (digitizer) 101, and the information processing apparatus instructs the user to trace the graphical pattern.   This graphical pattern is not limited to a character, and may be a circle or the like. Any pattern may be used as long as the pattern represents a graphic image or a character capable of providing enough samplings.   The total number of samplings is divided by the time for which the pen is in contact with the digitizer, that is, the total of time for which the digitizer detects the position of the pen, thereby determining the number of samplings per unit time.   Typically, the unit time is one second, and the number of samplings per unit time may vary from 10 to 1000.

[0039]   The number of samplings per unit time which is determined by the sampling rate detector 103 is usually

greater than needed. In other words, there is a sufficient, or rather excessive, number of samplings in order to express smooth and natural strokes using sequences of points. One problem associated with an excessive number of samplings is

5 sensitivity to various noise, causing jagged strokes. Basically, the preferable number of samplings is about 20 points per second, and this number of samplings may be set for a standard stroke.

[0040] The number of samplings per unit time which is

10 determined by the sampling rate detector 103 may vary depending upon the state of the information processing apparatus connected to the digitizer. However, since the number of samplings is inherently unique to a digitizer and an information processing apparatus, the number of samplings

15 which is defined when the driver for the digitizer is installed would be semi-permanently used.

[0041] The process executed by the writing data standardizer 104 is described below with reference to Fig. 4.

[0042] Fig. 4 is a flowchart of the process executed by

20 the writing data standardizer 104 according to the first embodiment.

[0043] As described with respect to Fig. 3, user writing data which is input through a digitizer principally has a larger number of samplings than the number of samplings of

25 the above-described standard stroke. Therefore, it is

necessary to decimate some sampling points which are included in the user writing data. The process to decimate sampling points is illustrated in Fig. 4.

[0044] At step S501, sampling points of the writing data to be processed are captured from the beginning. Each time a sampling point is captured, the loop from step S501 to step S504 is repeated. The loop starts at step S501, where the loop variable is indicated by "i" and starts at zero. This is expressed in the C language as follows:

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for(i=0; i<N; i++) {description of the process}
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where N denotes the number of sampling points of the writing data.

[0045] In Fig. 4, it is assumed that the writing data has 500 sampling points per second, while the standard stroke has 20 sampling points per second. Then, 24 points must be decimated every 25th point. This is performed at determination step S502, where M is 25 in this example. More generally, it is determined at step S502 whether or not the loop variable is divisible by M. If the loop variable is not divisible by M, i.e., if NO is obtained at step S502, the process proceeds to step S504. Otherwise, i.e., if the loop variable is divisible by M, the process proceeds to step S503, in which the sampling point to be processed is set into a standardized writing data register.

[0046] It is determined at step S504 whether or not there

is a sampling point of the writing data to be processed. If the sampling point is present, or YES is obtained at step S504, the sampling point to be processed increments by one, and the process returns to step S501. Otherwise, or if the sampling point is not present at step S504, the process proceeds to step S505.

[0047]   At step S505, the end point of the sampling point of the writing data to be processed is set into the standardized writing data register.

[0048]   In the flowchart of Fig. 4, the starting point has a loop variable of 0, by which any number is divisible. Thus, the sampling point of the starting point of the writing data is always set into the standardized writing data register. Next, the sampling point having a loop variable of 25 is set into the standardized writing data register, followed by the sampling point having a loop variable of 50, and so on. Accordingly, the sampling points having a loop variable of multiples of 25 are in turn set into the standardized writing data register. After the sampling points of the writing data to be processed have been all processed and the end point of the sampling point has been set into the standardized writing data register, the trajectory of the sampling points that have been set into the standardized writing data register corresponds to the standardized writing data.

[0049]   If the number of samplings in the writing stroke which is input through the digitizer is smaller than the number of samplings of the standard stroke, sampling points must be interpolated between the sequence of sampling points of the input writing data to create a standardized writing stroke.   The process to interpolate sampling points is described below with reference to Figs. 5 to 8.   The interpolation method basically includes adding virtual timestamps to the sampling points of the writing data, and adding new sampling points between the sampling points based on the timestamps.

[0050]   The data structure of time-stamped writing data is described below with reference to Fig. 5.

[0051]   Fig. 5 is a table of an example data structure of time-stamped writing data according to the first embodiment.

[0052]   The time-stamped writing data is made by virtually adding the absolute time of the sampling point (timestamp information) to the writing data input through a digitizer. The timestamp information allows the user to know the interval of the sampling time from the sampling rate. Therefore, the number of a sampling point from the starting point of sampling is studied to readily determine the absolute time of the sampling point.   Fig. 5 shows the timestamp information in a table, in which the time at which the corresponding sampling point was captured is presented

in the last column for each row.

[0053]   The time-stamped writing data shown in Fig. 5 is
constructed by adding the timestamp information to four-
dimensional writing data. Generally, timestamp information
is added to n-dimensional writing data to generate (n + 1)-
dimensional data, which is called time-stamped writing data.
The writing data includes x-coordinates and y-coordinates of
data which is input by a user through a digitizer, writing
pressure information, and writing speed information.

[0054]   The operation of the writing data standardizer 104
is described below with reference to Fig. 6.

[0055]   Fig. 6 schematically shows the operation of the
writing data standardizer 104 according to the first
embodiment.

[0056]   The zigzag line plotted in Fig. 6 schematically
indicates the writing data, in which a black circle denotes
a sampling point (= writing data) and a white circle denotes
a standardized sampling point (= standardized writing data).
The standardized writing data is made by linearly
approximating between the time-stamped writing data. Herein,
a data group of the sampling points is indicated by X, and a
data group of the standardized sampling points is indicated
by Y. Both X and Y shown in Fig. 6 are symbols indicating
n-dimensional vectors. Although both X and Y are
schematically plotted on a two-dimensional plane in Fig. 6,

they may be plotted so as to include sampling information from the digitizer, such as writing pressure information and writing speed information, in addition to the coordinate information.

[0057]   The timestamp information of the time-stamped writing data is indicated by t1, t2, t3, t4, etc., and the timestamp information of the standardized writing data is indicated by ty1, ty2, ty3, ty4, ty5, etc.   It is assumed that the time interval of the standardized writing data (reference sampling interval) is constant.

[0058]   The process executed by the writing data standardizer 104 is now described with reference to Fig. 7.

[0059]   Fig. 7 is a flowchart of the process executed by the writing data standardizer 104 according to the first embodiment.

[0060]   In the definition of the symbols in the flowchart of Fig. 7, the i-th (index "i") data in the data group X of the sampling points of the writing data input through a digitizer is indicated by X(ti), and j-th (index "j") data in the data group Y of the sampling points of the standardized writing data is indicated by Y(tyj).   According to this notation, the data group X of the input writing data corresponds to a set of X(ti), and the data group Y of the standardized writing data corresponds to a set of Y(tyj).

The point X(t1) is the starting point of the input writing

data, and coincides with the starting point Y(ty1) of the standardized writing data.

[0061]   Furthermore, in the definition of the symbols in Fig. 7, dt denotes the time interval between the last determined Y point and the next X point (dt = t(i+1) - tyj); T denotes the reference time interval (reference sampling interval) of the standardized writing data group Y; and "Previous point" indicates the X or Y point previous to a new Y point, and the "Previous point" and the X point next thereto are the basis for generating a new Y point.

[0062]   In the following description with respect to the flowchart of Fig. 7, equations are expressed in the C language.

[0063]   First, at step S801, the starting point is set. More specifically, the following equations are satisfied: i = 1, j = 1, ty1 = t1, Y(ty1) = X(t1), and Previous point = X(t1). Then, vector X(t1) and vector Y(ty1) are matched with each other, as shown in Fig. 6.

[0064]   Then, at step S802, dt (the time interval between the last determined Y point and the next X point) is calculated. This calculation is performed according to the following equation: dt = {t(i+1) - tyj}.

[0065]   At step S803, it is determined whether or not dt > T. If dt > T, or YES is obtained at step S803, the process proceeds to step S808. Otherwise, or if NO is obtained at

step S803, the process proceeds to step S804.

[0066]   For example, if Y is on Y(ty2) and X is on X(t1)
in Fig. 6 (i = 1 and j = 2), then dt ≤ T.   Then, the process
proceeds to step S804.   If Y is on Y(ty3) and X is on X(t2)
(i = 2 and j = 3), then dt > T.   Then, the process proceeds
to step S808.

[0067]   At step S804, X to be processed is shifted to the
next X.   Specifically, "i" increments.   At step S805,
"Previous point" is set as X to execute "Previous point =
X(ti)."   At step S806, it is determined whether or not the
termination condition is satisfied (whether or not "Previous
point" reaches the end point of X, i.e., i = n).   If the
termination condition is not satisfied, or NO is obtained at
step S806, the process returns to step S802.   If the
termination condition is satisfied, or YES is obtained at
step S806, the process to create standardized writing data
is completed.

[0068]   At step S808, new Y is created.   Specifically, the
point which is on a straight line connecting a vector
"Previous point" to a vector X(t(i+1)) and which is (T-
((previous_time)-tyj)) later than "Previous point," that is,
the point prior to X(t(i+1)) by (dt-T), is approximated, and
the result is set as the next Y.   As used herein,
"previous_time" indicates timestamp information of "Previous
point."   Hence, the vector equation to calculate the new Y

is as follows:

$$Y(yt(j+1)) = X(t(i+1)) + (Previous\ point - X(t(i+1)))\ *$$

$$(dt - T)/(t(i+1) - previous\_time).$$

At the same time, $yt(j+1) = ytj + T$ is also calculated.

This is geometrically plotted in Fig. 8 using a vector space model.

[0069]   After the new Y has been created, at step S809, Y to be processed is shifted to the next Y (the newly created Y). Specifically, j increments.

[0070]   At step S810, "Previous point" is set as Y. Specifically, "Previous point = $Y(tyj)$" is calculated. Then, the process returns to step S802.

[0071]   As above described, in the first embodiment, the standardized writing data which is obtained by standardizing the writing data which is input through the coordinate input device is managed. This ensures precise signature verification on the input writing data having a resolution with a low sampling rate.

[0072]   Furthermore, a single program which is installed in an information processing apparatus having different kinds of digitizers would support all digitizers.

[0073]

Second Embodiment

In the first embodiment, signature verification of a user who uses the information processing apparatus has been

described. The components of the information processing apparatus in the first embodiment may be incorporated into a server or client device in a server-client signature authentication system to embody the present invention. For

5   example, the client may include the coordinate input device 101, the sampling rate detector 103, and the writing data standardizer 104 shown in Fig. 1, and the server may include the signature register 106, the signature dictionary database 107, the signature verifier 108, and the

10   verification result output unit 109 shown in Fig. 1, so that the client and the server can transmit and receive data to and from each other over a network. In this case, if the client has different kinds of digitizers, writing data is standardized and the standardized writing data is

15   transmitted to the server, allowing the server to facilitate signature authentication. If a user uses a client having a different kind of digitizer from the client which is used by the user to register his/her signature, the signature can be verified by the server.

20   [0074]   Accordingly, if a plurality of clients linked to a server have different performances, or if coordinate input devices linked to the clients have different performances (such as sampling rate), signature authentication would also be achieved.

25   [0075]

Third Embodiment

In a third embodiment of the present invention, the above-noted standardized writing data 105 is used for handwritten character recognition instead of signature authentication.

[0076]   Fig. 9 is a block diagram of an information processing apparatus according to the third embodiment.

[0077]   The same reference numerals designate the same components as those in the information processing apparatus shown in Fig. 1, and the description thereof is thus omitted.

[0078]   In the context of handwritten character recognition, a feature extractor 206 extracts features of the standardized writing data 105.   A character recognizer 208 refers to dictionary data 207, in which extracted features of standard characters are accumulated in advance, to perform character recognition on the standardized writing data 105.   A recognition result output unit 209 outputs character code strings corresponding to the recognition result of the character recognizer 208.

[0079]   Accordingly, in the third embodiment, the writing data which is input through a coordinate input device is standardized, and the standardized writing data is used to perform character recognition on the input writing data. This ensures precise signature verification on the input writing data having a resolution with a low sampling rate.

[0080]

Fourth Embodiment

In a fourth embodiment of the present invention, the above-noted standardized writing data 105 is used for a handwriting word processor instead of signature authentication.

[0081]   Fig. 10 is a block diagram of an information processing apparatus according to the fourth embodiment.

[0082]   The same reference numerals designate the same components as those in the information processing apparatus shown in Fig. 1, and the description thereof is thus omitted.

[0083]   In the context of a handwriting word processor, a writing data register 306 registers the standardized writing data 105 into a stroke database 307. The writing data 102 is not directly registered into the stroke database 307, but is standardized before being registered into the stroke database 307.

[0084]   Accordingly, in the fourth embodiment, the writing data which is input through a coordinate input device is standardized, and the standardized writing data is used to output stroke data. Therefore, stroke data having more suitable configurations can be output. When the stroke database 307 is searched for arbitrary stroke data, particularly, when the writing data which is input by the client having a different kind of digitizer in a server-

client database system is transmitted as a search parameter to the server, that writing data is standardized and the standardized writing data is used as a search parameter to execute searching. Therefore, search that does not differ

5   from person to person can be efficiently and precisely executed.

[0085]

Other Embodiments

An information processing apparatus according to any one of the first to fourth embodiments comprises components

10   (not shown) constituting a general-purpose computer such as a personal computer or a workstation, including a keyboard, a mouse, a display, a CPU, a RAM, and a ROM.

[0086]   Of course, the foregoing object of the present

15   invention is also achieved by incorporating a storage medium having program code of software implementing the features of the above-described embodiments recorded therein into a system or an apparatus, and by allowing a computer (or CPU or MPU) in the system or the apparatus to read and execute

20   the program code stored in the storage medium.

[0087]   In this case, the program code read from the storage medium implements the features of the illustrated embodiments. Therefore, the storage medium having the program code stored therein embodies the present invention.

25   [0088]   Storage media which provide program code include a

floppy disk, a hard disk, an optical disk, a magneto-optical
disk, a CD-ROM, a CD-R/RW, a DVD-ROM/RAM, a magnetic tape, a
nonvolatile memory card, and a ROM.

[0089]   The program code read by a computer is executed to

5   implement the features of the illustrated embodiments.   In
addition, the program code may instruct the operating system
(OS) running on the computer to execute a part or all of the
actual process, thereby implementing the features of the
illustrated embodiments.   This case is also encompassed by

10   the present invention.

[0090]   The program code read from a storage medium is
written to a memory mounted on a function expansion board
inserted into a computer or on a function expansion unit
connected to a computer.   Thereafter, the program code

15   instructs a CPU or the like mounted on the function
expansion board or the function expansion unit to execute a
part of all of the practical process, thereby implementing
the features of the illustrated embodiments.   This case is
also encompassed by the present invention.

20   [0091]   The storage medium for which the present invention
is implemented will store program code corresponding to the
process as previously described with respect to the
flowcharts.

[0092]   As described above, according to the present

25   invention, signature verification would be performed on

writing data which are input using different kinds of digitizers.

[0093]   While the present invention has been described with reference to what are presently considered to be the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. On the contrary, the invention is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.